

National Aeronautics and Space Administration



Marshall Space Flight Center Space and Missile Defense Symposium

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marshall



Thank you for having me here today.

I am really glad to be included in this discussion because we don't always pair NASA with many of the groups here today, we all share a similar mission. The intersection of our needed technologies is significant. Different purposes but with similar technologies.

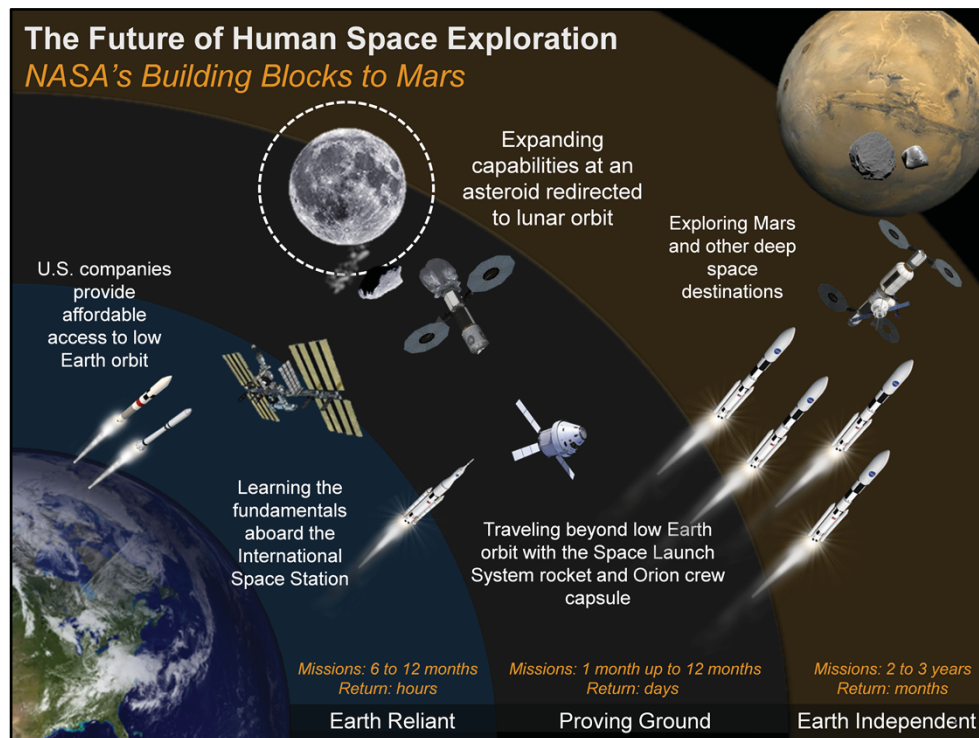
Whether you are in defense of the homeland or civil space, all our work is a part of our national space program.

Different players, same team.



At NASA, our technology concentration is technology that drives exploration-exploration with humans and robotics. Exploration driven by our need to explore and exploration to execute science.

As I have said, Some of our technologies are unique to NASA but many are either synergistic or even critical to both civil and defense space. Often times there are examples where one of us or the other has created a paradigm shift in capability that has benefitted the other.




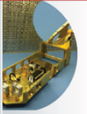





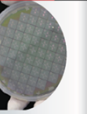
Here is a snapshot of the Agency's human exploration goals.

We've made a lot of advancements in technology applications in low Earth orbit. And we will continue to make those types of advancements- expanding from low Earth orbit and establishing deep space exploration.

The future is deep space. Bolden has issued a challenge for us to send humans to an asteroid by 2025 and to Mars in the 2030.

We are going to have to rely on advanced technology to get us there.

STEP THROUGH THE SLIDE, LEFT TO RIGHT, LEO to Mars

Eight Key Thrust Areas							
							
High Power Solar Electric Propulsion	Space Optical Comm.	Advanced Life Support & Resource Utilization	Mars Entry Descent and Landing Systems	Space Robotic Systems	Lightweight Space Structures	Deep Space Navigation	Space Observatory Systems
Deep space human exploration, science missions and commercial applications with investments in advanced solar arrays and advanced electric propulsion systems, high-power Hall thrusters and power processing units.	Substantially increase the available bandwidth for near Earth space communications currently limited by power and frequency allocation restrictions, and increase the communications throughput for a deep space mission.	Technologies for human exploration mission including Mars atmospheric in-situ resource utilization, near closed loop air revitalization and water recovery, EVA gloves and radiation protection.	Permits more capable science missions, eventual human missions to Mars including, hypersonic and supersonic aerodynamic decelerators, a new generation of compliant TPS materials, retro-propulsion technologies, instrumentation and modeling capabilities.	Creates future humanoid robotics, autonomy and remote operations technologies to substantially augment the capability of future human space flight missions.	Targets substantial increases in launch mass, and allow for large decreases in needed structural mass for spacecraft and in-space structures.	Allows for more capable science and human exploration missions using advanced atomic clocks, x-ray detectors and fast light optical gyroscopes.	Allows for significant increases in future science capabilities including, AFTA/ WFIRST coronagraph technology to characterize exo-planets by direct observation and advances in the surface materials as well as control systems for large space optics.

Our technology needs and challenges for reaching greater destinations are pretty clear. This is from NASA's Associate Administrator for Space Technology. This comes from a more detailed roadmap, but with current resources these are the current focus areas of Space Technology.

To get there and back we are going to need a heavy lift rocket. A rocket like SLS. We will also need rendezvous and docking, and a life support system that is the cornerstone. We need to be able to withstand the deep space environment- hot, cold and radiation, especially radiation. Reduced trip times and shielding are critical. Because of the distance and duration, you have to consider maintenance, spares, resupply, etc. [Analogy: a trip in your boat from DC to Mt. Vernon is very different than a round-the-world trip with only one stop... there is paradigm shift in requirements.]

To live in deep space you have to consider a host of things: radiation, waste management, and life support systems.

To be productive in deep space we have to be equipped to do something when we get there.

And of course landing on Mars is much more complex landing once we get there. Landing a Rover on Mars is complex, landing humans an order of magnitude more complex.

Quick left to right.... Prop for Cargo capability, rapid and high throughput communications, High recapture and recycle for life support systems, Landing in the inhospitable and unpredictable Martian atmosphere, robotics as work multipliers and assembly in space, lightweight (the “gear” ratios to Mars) structures, deep space navigation, and science observatory systems (doing groundbreaking science, like large space optics)



This is a snapshot of the Agency's technology events and milestones. Marshall has leading roles in the items you see in orange. Anything beyond 2015 is of course somewhat contingent on funding and further approval, but this is the framework for the future.

At Marshall, we have a diverse technology portfolio, and I couldn't mention or highlight all of our work in 15 minutes so I have tried to hit the high notes.

Major technology priorities includes nuclear propulsion, cryogenics storage, advanced manufacturing (composites and metallic) and smallsats, especially smallsat propulsion systems - all of which have the capability to enable greater advancements for exploration and science missions. Marshall also places great value on technologies that allow for low cost access to space and enable better x-ray optics, etc.

Demonstrate the Viability of Nuclear Propulsion Technologies



Marshall is engaged in a three year technology demonstration project to perform realistic, non-nuclear testing of various materials.

We have been able to develop and fabricate nuclear fuel elements, and perform testing within the same temperatures and pressures as a high performance engine designed for the future of rocket propulsion.

Building in space capability that more than doubles the best that chemical propulsion ISP can do is important to deep space exploration. Reducing trip time and increasing mass capability (more shielding, more supplies, etc,) makes it more likely.

Tech Development- Cryogenics



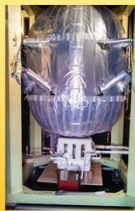
In 2013, MSFC successfully tested a 8-ft/2.4m composite cryotank.



In March, the 5.5m composite cryotank arrived via super guppy.



Testing of the 5.5m tank began in May and concludes in August.



Engineering Development Unit

Marshall completed hydrogen and nitrogen testing of the EDU in July.

The Agency and Marshall have been steadily working on new and advanced space-based cryogenic applications.

With cryogenics, we have to be able to do a couple things. At Marshall we have one initiative to reduce cost and weight in regard to launch vehicles and other spacecraft system designs.

In 2013, we successfully tested a 2.4m composite cryotank. We have since moved on to testing the 5.5m composite cryotank.

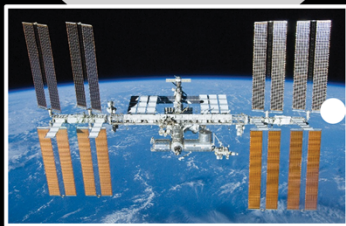
With respect to storage and transfer

Marshall tested an engineering development unit, as a technology demonstration, to show that it is possible to store, transfer, and measure cryogenic propellants in orbit for longer durations valuable for deeper human space exploration. We came up with a number of new techniques to measure and help control the cryogenics in a space like environment. This is important since Liquid cryogenics boil off in space. You can imagine if your car today was losing fuel while in this presentation. Another tough but solvable hurdle to deep space exploration.

Tech Development- Advanced Manufacturing



In 2013, MSFC test fires 3D printed rocket fuel injector.



3D space printer is awaiting its Space-X launch in Sept. to ISS.



MSFC completed its verification testing in May.



MSFC received 3D space printer in March.

Marshall had a previous successful test of the largest single 3D printed item ever used in rocket fire test. We will continue progress towards significantly reducing manufacturing costs of flight hardware.

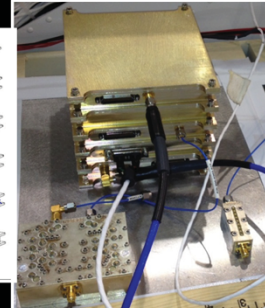
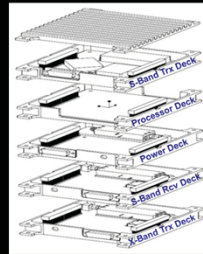
Marshall has worked with Made in Space, Inc. to launch the first 3D printer to space this year. This effort began as a SBIR with MIS and was one of the projects highlighted by the President at the White House Maker Faire event in June. This 3-d printer will be responsible for building space station's spare parts, as well as tools and upgrade materials if they are damaged or improved- giving astronauts greater flexibility and saves the Agency time and mass, all of which ultimately mean cost savings. A proving ground on building a "machine shop" if you will that can go beyond stunts and actually replace parts on the ISS.

Tech Development- Smallsats



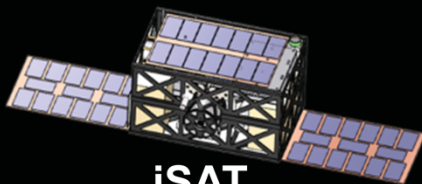
FASTSAT

2010-2012
MSFC-built and
launched
nanosatellite from
a microsatellite



PULSAR

Programmable Ultra Lightweight
System Adaptable Radio



iSAT

Iodine Satellite

We want to be able to do the real missions. To do that, we need better advancements in propulsion, power and communications.

We are expanding on our previous success with FASTSAT (which Dynetics was a key player in), and working on a suite of concepts and technology demonstrations to advance small sat technologies.

In particular I will mention iSAT. iSAT is a technology demonstration mission to demonstrate the use of a iodine for greater thrust-to-mass ratios in a cube sat architecture. Right now it is the concept review stage, but we are building parts as we speak. Small sats are great, but without real propulsion they are not very capable.

Marshall is also working on a technology known as PULSAR which will offer a radiation tolerant SDR transponder. We have tested PULSAR already on a small balloon (with the next plan, SLS) and the outcomes are really impressive- this transponder will be more capable and more importantly have lower cost.

Tech Development- Low Cost Access to Space



Hi-C

High Resolution Coronal Imager



MSFC Nanolaunch



SWORDS

Engine Testing

I would be amiss if I didn't mention a few of the ways we are gaining low cost access to space.

Marshall is engaged in developing nanolaunch vehicles, which you will hear about in more detail in the NASA panel later today.

Our sounding rocket program has launched Marshall-developed, highly sophisticated optics into LEO that have celebrated unique successes such as capturing the highest-ever resolution images of the Sun. We really want to be able to go orbital at the same price as sub-orbital.

Marshall also just finished testing the largest liquid methane fuel and liquid oxygen engine for SMDC's nano-launch vehicle known as SWORDS.

Team Redstone



Together, We Make Bold Things Happen



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